VI. Improving Grid Transparency Through Hosting Capacity Analyses and Other Tools

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A. Introduction and Problem Statement

Storage can provide energy to, and charge from, the grid in a controlled manner that avoids or minimizes the need for upgrades while providing valuable grid services. However, to optimally design storage to provide these benefits, access to information about the distribution grid and its constraints is needed to inform where and how to interconnect storage.

Currently, the information about distribution grid equipment and constraints that is needed to select sites and design site-specific operating profiles is largely inaccessible to those looking to install storage. Limited information around distribution system needs and constraints forces customers to submit interconnection applications and operating profiles for projects that may not be properly tailored to a grid location. The evaluation of interconnection applications for ESS that are not optimized for their grid location results in wasted time and resources for both the interconnection customer and the utility. In addition, areas of the grid that can benefit from storage services may receive less focused attention or poorly designed projects. For these reasons, limited grid transparency is a barrier both to realizing the benefits of ESS for the grid and to ESS interconnection.

Utilities' distribution system information is typically available to customers only through mechanisms that interconnection procedures or regulatory orders require. This toolkit provides stakeholders insights into information transfer options. It addresses practical methods and related requirements for the provision of distribution system data to ESS customers.

Hosting capacity analysis (HCA) is a complex analytical approach that uses power flow simulations to evaluate how the distribution grid performs with the addition of new DERs. It is a modern procedure that provides detailed and sophisticated distribution system analyses to utility engineers, customers, and state regulators. When HCA results are provided on an hourly basis, developers can use them to guide the design of ESS sizing and operation to avoid negative impacts on the grid and provide energy and other services when grid constraints allow it. In addition, if the HCA is used in the interconnection process, it can help screen for potential grid impacts caused by a proposed ESS project, facilitate more efficient application processing, and encourage better system design. There is some disagreement among stakeholders on how much an HCA analysis can be relied on to precisely design ESS operating profiles or to make decisions in the interconnection process; those points of disagreement are discussed further in the Recommendations section below.

Less sophisticated tools, including pre-application reports and "basic distribution system maps" that provide fixed grid data (and thus differ from HCA maps, as described above), are more commonly used today. However, for energy storage projects to provide many of their most valuable grid services, developers would benefit from more information than has typically been shared in the past for solar-only projects. This chapter first discusses how to use the less complex approaches available today and then how to adopt HCAs as a more granular and sophisticated tool that estimates time-varying grid constraints.

B. Recommendations

1. Providing Data via Pre-Application Reports and Basic Distribution System Maps

Utilities often provide pre-application reports so that customers seeking to interconnect DERs can understand the state of the distribution system at the Point of Interconnection (POI). The pre-application report is part of SGIP and is considered a “best practice;” the suggested price point is $300 per report. Pre-application reports are typically provided 10 days after a customer submits a request and pays a fee. In some cases, utilities also publish basic distribution system maps that provide some similar information and can be accessed by developers and others via the internet at any time at no cost. It should be noted, however, that the amount of data available in system maps can vary depending on the regulatory requirements, feasibility, and cost required for utilities to collect and format it in a publicly accessible manner.

A list of data that developers commonly request to be included in pre-application reports and basic distribution system maps is provided below. Both pre-application reports and basic distribution system maps are still evolving at many utilities, and the data being shared is driven by regulatory requirements and what data may be available. Utility time and resources are required to acquire and package the data in a publicly accessible format and the accessibility of the data varies by utility. Stakeholders have different views on the value of providing all of this information to customers. The list below includes the information fields most often requested; they are not universally available within different utility jurisdictions.

<u>Requested Pre-Application Report Data</u>

- Total capacity of substation/area bus or bank and circuit likely to serve proposed site
- Aggregate existing generating capacity interconnected to the substation/area bus or bank and circuit likely to serve proposed site
- Aggregate queued generating capacity proposing to interconnect to the substation/area bus or bank and circuit likely to serve proposed site
- Available capacity[73] of substation/area bus or bank and circuit likely to serve proposed site

[73] Available capacity is the total capacity less the sum of existing and queued generating capacity, accounting for all load served by existing and queued generators.

- Whether the proposed generating facility is located on an area, spot, or radial network
- Substation nominal distribution voltage or transmission nominal voltage if applicable
- Nominal distribution circuit voltage at the proposed site
- Approximate circuit distance between the proposed site and the substation
- Load profile showing 8760 hours, by substation and transformer, when available
- Relevant line section(s) actual or estimated peak load and minimum load data, when available
- Number and rating of protective devices, and number and type of voltage regulating devices, between the proposed site and the substation/area
- Whether or not three-phase power is available at the site and/or distance from three-phase service
- Limiting conductor rating from proposed Point of Interconnection to distribution substation
- Based on proposed Point of Interconnection, existing or known constraints such as, but not limited to, electrical dependencies at that location, short circuit interrupting capacity issues, power quality or stability issues on the circuit, capacity constraints, or secondary networks
- Any other information the utility deems relevant to the applicant

<u>Requested Basic Distribution System Map Data</u>

Substation

- Name or identification number
- Voltages
- Substation transformer’s Nameplate Rating
- Existing generation (weekly refresh is desired)
- Queued generation (weekly refresh is desired)
- Total generation (weekly refresh is desired)
- Load profile showing 8760 hours, by substation and transformer
- Percentage of residential, commercial, industrial customers
- Currently scheduled upgrades
- Has protection and/or regulation been upgraded for reverse flow? (yes/no)
- Number of substation transformers and whether a bus-tie exists
- Known transmission constraint requires study
- Notes of any other relevant information to help guide interconnection applicants, including electrical restrictions, known constraints, etc.

Feeder

- Feeder name or identification number
- Substation the feeder connects to
- Feeder voltage

- Number of phases
- Substation transformer the feeder connects to
- Feeder type: radial, network, spot, mesh, etc.
- Feeder length
- Feeder conductor size and impedance
- Service transformer rating
- Service transformer daytime minimum load
- Existing generation (weekly refresh is desired)
- Queued generation (weekly refresh is desired)
- Total generation (weekly refresh is desired)
- 8760 load profile
- Percentage of residential, commercial, industrial customers
- Currently scheduled upgrades
- Federal or state jurisdiction
- Known transmission constraint requires study
- Notes of other relevant information to guide interconnection applicants

How Customers Can Use Distribution System Data to Help Site and Guide ESS System Design and Installation

Below is a description of how customers can use distribution system data to help inform ESS siting and design. Note: The data discussed below is not always available to or provided by utilities today. Moreover, leveraging distribution system data to inform ESS sizing and design would not supplant utility review; review would still be required and could change design and siting outcomes.

Map of Distribution System Lines. A customer can use the location of distribution system lines to determine what feeder (also called a circuit) they are closest to and to design the project to be compatible with that feeder's characteristics. If there are multiple potential POIs for a project, a customer can identify the differences in the distribution system at those locations and select the one most suitable for that project.

Existing and Queued Generation. Customers can use the quantity of existing and queued generation on a feeder to make a rough estimate of the likelihood that a new Interconnection Request will require study or upgrades. Feeders with a high quantity of existing generation are generally more likely to require study or upgrade. The same is true with queued generation, although there is more uncertainty associated with queued generation because a customer can cancel the project and withdraw it from the queue. HCA results provide a more precise estimate of the actual available capacity.

Load Profile. Customers and developers use load profiles to strategically locate ESS to provide energy during peak load hours and to minimize export during low load/high generation hours. For example, a customer seeking to site a new solar project with ESS could use a load profile that avoids expensive distribution system upgrades by designing a system that accommodates daily or seasonal variations in minimum load with voluntary seasonal or hourly export limits. In addition, a customer seeking to site standalone ESS can use the peak load on a feeder to understand the magnitude of the proposed new load compared to the existing peak loads. Note: When a utility shares load profiles, it will need to aggregate or redact the data to protect customer privacy according to a state's regulatory guidance.

Feeder/Substation Characteristics. Information about the voltage of the line, number of phases, presence and rating of voltage regulating devices, and other specific technical information about the grid conditions at the POI enables customers to understand how to size a system and what types of changes may be needed to avoid upgrades. For example, large ESS will likely need to connect directly to a three-phase line.

Notes. Customers often get useful data from notes that engineers add about the known constraints on, or characteristics of, a feeder. For example, the notes field might indicate that recent interconnection studies on the feeder found that voltage issues constrain available hosting capacity, certain equipment was recently installed, or the feeder is abnormally configured.

2. Hosting Capacity Analysis Maps and Results

In states where hosting capacity maps are being developed, some utilities begin by publishing basic distribution system data maps (like those mentioned above) as an interim step before full hosting capacity results are added.[74] This is due to the time and resources required to gather data and develop the models and analysis for HCA.[75] Producing HCA results involves gathering information about the distribution grid, including the physical infrastructure (the wires, voltage regulating devices, substations, transformers, etc.), the type and performance of load on the grid (load curves showing maximum and minimum load), and the existing DERs (including rooftop solar, ESS, etc.).

This data is then input into an electronic feeder model to create a "base case" for existing grid conditions. In the transmission system interconnection process, developers can

[74] *See, e.g.,* CA Pub. Util. Comm., Dkt. 08-08-009, Renewables Portfolio Standard, Decision 10-12-048, Decision Adopting the Renewable Auction Mechanism, pp. 70-72 (Dec. 17, 2010) (adopting the first basic distribution map in California); Electric Power Research Institute, *Defining a Roadmap for Successful Implementation of a Hosting Capacity Method for New York State*, p. 8 (June 20, 2016), https://www.epri.com/research/products/000000003002008848.

[75] *See* Electric Power Research Institute, *Defining a Roadmap for Integrating Hosting Capacity in the Interconnection Process* (Oct. 28, 2020), https://www.epri.com/research/programs/108271/results/3002020010.

request access to electronic copies of these base case models via FERC Form 715.[76] This enables developers to perform their own power flow analysis of the impact of adding new resources. This practice is not currently performed at the distribution system level. States may wish to examine whether it is feasible and beneficial to provide electronic distribution system base case models to DER developers under appropriate agreements.

In creating an HCA, utilities use the base case to perform power flow simulations to evaluate how the distribution grid performs with the addition of new generation and load at specific locations. Significant variations among grid conditions are evaluated to get a full understanding of the grid constraints. While HCAs are a powerful simulation, the modeling exercise is complex and not all grid conditions are necessarily considered in the way they might be for a full system impacts study.[77]

a. Hosting Capacity Analyses as Information Tools to Guide ESS Design

The number of hours analyzed in the HCA's power flow simulation informs if the HCA can be used by developers to design ESS parameters that capture the benefits discussed above: avoiding negative impacts on the grid, benefiting the grid, and streamlining the interconnection process. HCAs that provide hourly and seasonal results allow developers to design ESS projects that limit output during hours when the grid has too much energy (or other temporary constraints). When an HCA includes an analysis of the impacts of new loads, it can also be used to design ESS to charge when the grid has too much energy. Consequently, these systems can be designed to provide energy to the grid (or the customer) during the hours that it is needed most. An important limitation to consider, however, is that the grid constraints provided through the HCA are dependent on the quality of the data and modeled conditions on the feeder. HCA models are typically based upon load data from previous years. Load and generation on a feeder may be unpredictable and change over time. Therefore, grid constraints produced through the HCA are an estimate based on previously known conditions and should be treated as such when sizing and designing ESS projects.

Due to potential changes in load and generation patterns, stakeholders disagree on the extent to which a customer can design a system to match the hourly or seasonal constraints using just the HCA results. In concept, an HCA that provides hourly grid constraints gives customers the flexibility to propose solar-plus-storage projects that limit export only during the most restrictive hours. For example, a line section may be able to support a 2 MW solar generator most of the year, but only a 1 MW solar generator from 10

[76] 18 Code of Federal Regulations § 141.300; Federal Energy Regulatory Commission, *Filing Form No. 715 Annual Transmission Planning and Evaluation Report*, https://www.ferc.gov/industries-data/electric/general-information/electric-industry-forms/filing-form-no-715-annual (last accessed Aug. 11, 2021) ("Part 2, Power Flow Base Cases; Part 3, Transmitting Utility Maps and Diagrams").

[77] There are tradeoffs to consider in terms of the creation of HCA maps. They require utility time and resources to both create and maintain. Considerations should weigh the relative cost and usefulness of map features and functionalities, data granularity, and update frequency.

AM–3 PM in March and April. An HCA with hourly results would allow a customer to propose a 2 MW system and agree to limit its export to 1 MW during those hours in the spring when the constraints arise. The excess solar would be stored by the ESS and released at a later time, such as after the sun sets.

Similarly, an HCA that provides hourly grid constraints may also offer customers the ability to propose an ESS as a flexible load that charges from the grid only when there is available capacity on the grid. For example, if a line section could support 2 MW of new load from 10 AM–3 PM in March and April, but only 1 MW of new load at other times, an HCA with hourly load results would allow a customer to propose a 2 MW system and agree to limit its charging from the grid to 1 MW except during those hours in the spring when oversupply exists. Similarly, developers could utilize the HCA results to help design electric vehicle chargers with ESS to limit charging during times with constraints, such as during the existing net peak hours.

By limiting export to or charging from the grid in certain hours, the customer can build the DER at the desired size and ensure that energy is available when inflexible loads need it. Since capacity constraints typically correspond to periods of high or low energy demand, this enables ESS to serve peak loads more efficiently. If utilities identify other grid needs, the ESS customer could also explicitly agree to provide the services identified. Moreover, limiting export and charging to certain hours can also allow customers to avoid time-consuming interconnection studies and expensive grid upgrades.

For HCA to be used in this manner, stakeholders will need to understand that specific ESS designs predicated on HCA analysis are relying on modeled data. Hosting capacity values on a map provide a snapshot in time and often correspond to a specific DER technology and associated control. Moreover, they may not capture the latest grid or DER queue data because projects in the queue are considered tentative until they are interconnected. Any time-based HCA constraint curve is based upon the quality and accuracy of the data used and may not reflect how conditions change in the future. The constraints can abruptly change based on system configuration or the operation of connected devices such as generation. As a result, design decisions based exclusively on map data do not guarantee interconnection approval without upgrades. Regulators will need to take this into account as they consider how to best utilize HCA maps as an informational or decision-making tool. The manner in which the interconnection process should recognize and adapt to these unknowns is an open policy question.

b. Hosting Capacity Analyses as Decision-Making Tools in the Interconnection Review Process for ESS

One reason HCAs were originally developed was to further inform the interconnection screening process. The goal was to replace or supplement certain interconnection Fast Track screens that use a conservative approximation of feeder conditions with a more sophisticated power flow simulation of the actual conditions on the feeder that can provide more accurate results. HCA is capable of providing a more accurate assessment of impacts than is currently used in several of the more commonly failed screens in the Fast Track and

Supplemental Review process. Results may directly answer certain interconnection screens and can also be used to verify that the screening process as a whole correctly captures DER-related impacts. In short, hosting capacity results can be aligned to inform interconnection screening if the analyzed DER characteristics and conditions in the HCA are the same as those in the Interconnection Request.

For example, California has required the use of HCA results (or Integration Capacity Analysis, as HCA is called in California) instead of the 15% screen.[78] The 15% screen evaluates if the total generation on the feeder exceeds 15% of a line section's peak load. The 15% screen was designed as a conservative rule-of-thumb based on generic feeder assumptions to approximate when the increased penetration of DERs on a feeder could trigger voltage, thermal, and protection problems. In contrast, the HCA actually examines if the project will result in any specific voltage, thermal, and protection problems based on the historic load at that precise node, rather than using a heuristic that approximates problems based on a generic feeder. As a result, in certain circumstances. new DERs can interconnect safely using the Fast Track process even when the project would have failed the legacy 15% screen, and in others, it may flag an issue where the more generic screen failed to.

In contrast, the models and data that are used in HCA may lack the information needed to address screens that assess secondary or service transformer configuration and ratings. In general, HCA will not benefit screens that check for physical characteristics of the distribution system and cannot replace engineering judgment related to those characteristics. It is also important to note that there are potential impacts that current hosting capacity methods do not address, such as substation and transmission system impacts as well as secondary or low voltage impacts. Therefore, current HCA methods implemented by utilities alone cannot replace the entire screening process.

Publishing hourly HCA grid constraints and using those same HCA results in the interconnection process unlocks the potential for DER design improvements that can allow projects to more efficiently proceed through the interconnection process and into operation. As noted, there is disagreement on the extent to which the hourly HCA profile can be used as a final decision-making tool. Nevertheless, building on the example above, the customer could submit an interconnection application for a solar-plus-storage project with an export limit of 1 MW during the hours when the HCA identified that a constraint exists (from 10 AM–3 PM in March and April). Because the published HCA results, upon which the customer designed the project, would be the basis of certain Fast Track screens, the customer has a greater level of certainty that the project's operating profile would allow it to pass those Fast Track screens and avoid time-consuming interconnection studies and system upgrade costs.

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[78] CA Pub. Util. Comm., Dkt. R.17-07-007, Interconnection of Distributed Energy Resources and Improvements to Rule 21, Decision 20-09-035, *Decision Adopting Recommendations from Working Groups Two, Three, and Subgroup* (Sept. 30, 2020).

If used in this manner, HCA could help enable ESS to be designed in ways that address specific grid constraints and help to improve the efficiency of the interconnection process for DERs. As discussed, to unlock these benefits, HCAs would need to provide hourly information about grid constraints. At the same time, potential benefits would need to be weighed against the limitations of such an analysis to lock in an ESS design, as well as the costs to develop and maintain these complex analyses of hourly grid constraints. Future research could provide further clarity on these considerations. In addition, there are a variety of other issues that regulators, stakeholders, and utilities will need to consider when deciding how to implement an HCA, including:

- Use case
- Type of stakeholder engagement process
- Phased implementation process
- Methodology
- Update cycle
- Number and type of load hours for the analysis
- Whether the scope will include new load, new generation, or both
- Granularity of analysis and results
- Level of public access and security concerns, if any
- Level of data redaction to protect customer privacy
- Data validation process
- Limiting criteria and thresholds to use
- Cost of developing and maintaining maps

These identified issues are explored more fully in the guide, *Key Decisions for Hosting Capacity Analyses*, available on IREC's Hosting Capacity Analyses Resources webpage.[79]

[79] Sky Stanfield, Yochi Zakai, Matthew McKerley. *Key Decisions for Hosting Capacity Analyses*, Interstate Renewable Energy Council, pp. 15-17 (Sept. 2021), https://irecusa.org/resources/keydecisions-for-hosting-capacity-analyses.